(3) Calculate your corrected drag area for determining the aerodynamic bin by multiplying the measured zero-yaw drag area by CF_{ys}. The correction factor may be applied to drag areas measured using other procedures. For example, we would apply CF_{ys} to drag areas measured using the recommended coastdown method. If you use an alternative method, you would also need to apply an alternative correction ($F_{alt\text{-}aero}$) and calculate the final drag area using the following equation:

$$C_DA = F_{alt\text{-}aero} \cdot CF_{ys} \cdot (C_DA)_{zero\text{-}alt}$$

(4) You may ask us to apply CF_{ys} to similar vehicles incorporating the same design features.

(5) As an alternative, you may choose to calculate the wind-averaged drag area according to SAE J1252 (incorporated by reference in §1037.810) and substitute this value into the equation in paragraph (f)(2) of this section for the ±6° yaw-averaged drag area.

§ 1037.525 Special procedures for testing hybrid vehicles with power take-off.

This section describes the procedure for quantifying the reduction in greenhouse gas emissions as a result of running power take-off (PTO) devices with a hybrid powertrain. The procedures are written to test the PTO by ensuring that the engine produces all of the energy with no net change in stored energy. The full test for the hybrid vehicle is from a fully charged renewable energy storage system (RESS) to a depleted RESS and then back to a fully charged RESS. These procedures may be used for testing any hybrid architecture for which you are requesting a vehicle certificate using either chassis testing or powertrain testing. You must include all hardware for the PTO system. You may ask us to modify the provisions of this section to allow testing hybrid vehicles other than electric-battery hybrids, consistent with good engineering judgment.

(a) Select two vehicles for testing as follows:

(1) Select a vehicle with a hybrid powertrain to represent the vehicle family. If your vehicle family includes more than one vehicle model, use good engineering judgment to select the vehicle type with the maximum number of PTO circuits that has the smallest potential reduction in greenhouse gas emissions.

(2) Select an equivalent conventional vehicle as specified in §1037.615.

(b) Measure PTO emissions from the fully warmed-up conventional vehicle as follows:

(1) Without adding any additional restrictions, instrument the vehicle with pressure transducers at the outlet of the hydraulic pump for each circuit.

(2) Operate the PTO system with no load for at least 15 seconds. Measure the pressure and record the average value over the last 10 seconds (p_{min}). Apply maximum operator demand to the PTO system until the pressure relief valve opens and pressure stabilizes; measure the pressure and record the average value over the last 10 seconds (p_{max}).

(3) Denormalize the PTO duty cycle in appendix II of this part using the following equation:

$$p_{refi} = NP_i \cdot (p_{max} - {}_{min}) + p_{min}$$

Where:

p_{refi} = the reference pressure at each point i in the PTO cycle.

NP_i = the normalized pressure at each point i in the PTO cycle.

p_{max} = the maximum pressure measured in paragraph (b)(2) of this section.

p_{min} = the minimum pressure measured in paragraph (b)(2) of this section.

(4) If the PTO system has two circuits, repeat paragraph (b)(2) and (3) of this section for the second PTO circuit.

(5) Install a system to control pressures in the PTO system during the cycle.

(6) Start the engine.

(7) Operate the vehicle over one or both of the denormalized PTO duty cycles, as applicable. Collect CO_2 emissions during operation over each duty cycle.

(8) Use the provisions of 40 CFR part 1066 to collect and measure emissions. Calculate emission rates in grams per test without rounding.

(9) For each test, validate the pressure in each circuit with the pressure specified from the cycle according to 40 CFR 1065.514. Measured pressures must meet the specifications in the following table for a valid test:

TABLE 1 OF § 1037.525—STATISTICAL CRITERIA FOR VALIDATING DUTY CYCLES

Parameter	Pressure
Slope, $\|a_1\|$	$0.950 \le a_1 \le 1.030$.
Absolute value of intercept, $\|a_0\|$	≤2.0% of maximum mapped pressure.
Standard error of estimate, *SEE*	≤10% of maximum mapped pressure.
Coefficient of determination, r^2	≥0.970.

(10) Continue testing over the three vehicle drive cycles, as otherwise required by this part.

(11) Calculate combined cycle-weighted emissions of the four cycles as specified in paragraph (d) of this section.

(c) Measure PTO emissions from the fully warmed-up hybrid vehicle as follows:

(1) Perform the steps in paragraphs (b)(1) through (5) of this section.

(2) Prepare the vehicle for testing by operating it as needed to stabilize the battery at a full state of charge. For electric hybrid vehicles, we recommend running back-to-back PTO tests until engine operation is initiated to charge the battery. The battery should be fully charged once engine operation stops. The ignition should remain in the ''on'' position.

(3) Turn the vehicle and PTO system off while the sampling system is being prepared.

(4) Turn the vehicle and PTO system on such that the PTO system is functional, whether it draws power from the engine or a battery.

(5) Operate the vehicle over the PTO cycle(s) without turning the vehicle off, until the engine starts and then shuts down. The test cycle is completed once the engine shuts down. Measure emissions as described in paragraphs (b)(2) and (3) of this section. Use good engineering judgment to minimize the variability in testing between the two types of vehicles.

(6) Refer to paragraph (b)(9) of this section for cycle validation.

(7) Continue testing over the three vehicle drive cycles, as otherwise required by this part.

(8) Calculate combined cycle-weighted emissions of the four cycles as specified in paragraph (d) of this section.

(d) Calculate combined cycle-weighted emissions of the four cycles for vocational vehicles as follows:

(1) Calculate the g/ton-mile emission rate for the driving portion of the test specified in § 1037.510.

(2) Calculate the g/hr emission rate for the PTO portion of the test by dividing the total mass emitted over the cycle (grams) by the time of the test (hours). For testing where fractions of a cycle were run (for example, where three cycles are completed and the halfway point of a fourth PTO cycle is reached before the engine starts and shuts down again), use the following procedures to calculate the time of the test:

(i) Add up the time run for all complete tests.

(ii) For fractions of a test, use the following equation to calculate the time:

$$t_{test} = \frac{\sum_{i=1}^{N}\left(NP_{\text{circuit\_1,i}} \cdot NP_{\text{circuit\_2,i}}\right) \cdot \Delta t}{\sum_{i=1}^{N}\left(NP_{\text{circuit\_1,i}} \cdot NP_{\text{circuit\_2,i}}\right) \cdot \Delta t} \cdot t_{\text{cycle}}$$

Where:

t_{test} = time of the incomplete test.

i = the number of each measurement interval.

N = the total number of measurement intervals.

$NP_{\text{circuit—1}}$ = Normalized pressure command from circuit 1 of the PTO cycle.

$NP_{circuit—2}$ = Normalized pressure command from circuit 2 of the PTO cycle. Let $NP_{circuit—2}$ = 1 if there is only one circuit.

t_{cycle} = time of a complete cycle.

(iii) Sum the time from complete cycles (paragraph (d)(2)(i) of this section) and from partial cycles (paragraph (d)(2)(ii) of this section).

(3) Convert the g/hr PTO result to an equivalent g/mi value based on the assumed fraction of engine operating time during which the PTO is operating (28 percent) and an assumed average vehicle speed while driving (27.1 mph). The conversion factor is: Factor = (0.280)/(1.000 − 0.280)/(27.1 mph) = 0.0144 hr/mi. Multiply the g/hr emission rate by 0.0144 hr/mi.

(4) Divide the g/mi PTO emission rate by the standard payload and add this value to the g/ton-mile emission rate for the driving portion of the test.

(e) Follow the provisions of § 1037.615 to calculate improvement factors and benefits for advanced technologies.

[76 FR 57398, Sept. 15, 2011, as amended at 78 FR 36393, June 17, 2013]

§ 1037.550 Special procedures for testing hybrid systems.

This section describes the procedure for simulating a chassis test with a pre-transmission or post-transmission hybrid system for A to B testing. These procedures may also be used to perform A to B testing with non-hybrid systems.

(a) Set up the engine according to 40 CFR 1065.110 to account for work inputs and outputs and accessory work.

(b) Collect CO_2 emissions while operating the system over the test cycles specified in § 1037.510.

(c) Collect and measure emissions as described in 40 CFR part 1066. Calculate emission rates in grams per ton-mile without rounding. Determine values for *A*, *B*, *C*, and *M* for the vehicle being simulated as specified in 40 CFR part 1066. If you will apply an improvement factor or test results to multiple vehicle configurations, use values of *A*, *B*, *C*, *M*, k_d, and *r* that represent the vehicle configuration with the smallest potential reduction in greenhouse gas emissions as a result of the hybrid capability.

(d) Calculate the transmission output shaft's angular speed target for the driver model, $f_{nref,driver,}$ from the linear speed associated with the vehicle cycle using the following equation:

$$f_{\text{nrefi,driver}} = \frac{v_{cyclei} \cdot k_{\text{d}}}{2 \cdot \pi \cdot r}$$

Where:

v_{cyclei} = vehicle speed of the test cycle for each point, *i*, starting from *i* = 1.

k_d = final drive ratio (the angular speed of the transmission output shaft divided by the angular speed of the drive axle), as declared by the manufacturer.

r = radius of the loaded tires, as declared by the manufacturer.

(e) Use speed control with a loop rate of at least 100 Hz to program the dynamometer to follow the test cycle, as follows:

(1) Calculate the transmission output shaft's angular speed target for the dynamometer, $f_{nref,dyno,}$ from the measured linear speed at the dynamometer rolls using the following equation:

$$f_{\text{nrefi,dyno}} = \frac{v_{\text{refi}} \cdot k_{\text{d}}}{2 \cdot \pi \cdot r}$$

Where: